

# Chapter 2

---

## **DISEASE CHARACTERIZATION**

- 1) Characteristics of Viruses, Bacteria and Parasites**
- 2) Classification of Foodborne Illness**
- 3) Clinical Features of Foodborne Illness**
- 4) The Carrier State**

# DISEASE CHARACTERIZATION

### Introduction

The majority of foodborne diseases are caused by microbial pathogens such as **viruses**, **bacteria** and **parasites**. Although foodborne diseases are also caused by physical and/or chemical contamination, this chapter will focus primarily on the microbial agents. A list of foodborne diseases, including chemical contaminants, is provided in Table 2.5 at the end of this chapter.

One way of categorizing foodborne illness is:

**foodborne infection** (the organism in ingested food invades and multiplies in the intestinal lining OR the organism in ingested food invades, multiplies and produces a toxin while in the intestinal tract), and

**foodborne intoxication** (organism produces a toxin in food that is subsequently ingested).

These two categories are discussed further in this chapter.

## 1) Characteristics of Viruses, Bacteria and Parasites

### A. Viruses

Viruses are minute organisms, smaller than bacteria and parasites. **Viruses can only reproduce within living cells in the body of the host and cannot multiply in foods. However, some viruses remain infectious in the environment and thus be transported through food.**

Viruses that are associated with foodborne diseases are characterized by growth in the intestinal cells and subsequent excretion in the feces. More than 100 types of enteric viruses exist, although only a few have been proved to cause foodborne disease (e.g., rotavirus, hepatitis A, “small round-structured viruses,” such as the Norwalk and Norwalk-like agents). Although other viruses such as adenovirus can cause gastrointestinal illness, the mode of transmission is believed to be primarily person-to-person. **Foodborne viruses cause infection and not intoxication.**

Documentation of viral foodborne disease is scant. This is because of diverse symptoms (often mild illness), difficulty of detection of viruses in food, and difficulty of routine, conclusive diagnosis through stool specimens. Food usually becomes contaminated when it is handled by a person infected with a virus who has poor personal hygiene or when the food comes in contact with virus-laden sewage. It does not take a large quantity of virus

for infection. For example, a person with rotavirus diarrhea may excrete approximately a trillion infectious particles per milliliter of stool, but as few as 10 particles can cause illness. Additionally, excretion of viruses in feces may occur even if a person has no symptoms of GI illness.

Viruses are increasingly being recognized as significant causes of foodborne illness in the United States. Outbreaks of hepatitis A transmitted through food are recorded every year. During the 5-year period 1988-1992, hepatitis A virus ranked between fourth and seventh among the identified causes of foodborne outbreaks in the United States. In 1996, more than 250 people became sick in a single Massachusetts outbreak caused by a “small round-structured virus.”

### B. Bacteria

Bacteria are one-celled living microorganisms that have a cell wall. Bacterial cells vary in shape and range in size from about 1 micrometer ( $\mu\text{m}$ ), which equals one millionth of a meter, to 5 or 10 micrometers in length. In contrast to viruses, bacteria can be seen with a conventional microscope. **Bacterial cells increase when each cell divides into two, which grow to full size and divide into two again (two-fold division). Unlike viruses or parasites, bacteria ARE able to multiply in or on food. Under optimum conditions, large numbers can easily be achieved.** (See Chapter 7, Section 2-B for additional information on growth of bacteria.)

Some pathogenic bacteria, including *Bacillus cereus*, *Clostridium botulinum*, and *Clostridium perfringens*, form spores that can survive adverse environmental conditions. The spores germinate to form viable cells that increase to large numbers. Spore-forming pathogens are significant because when the spores occur in foods, they are more difficult to kill. For example, although *Bacillus cereus* bacteria survive up to 122° F, much higher temperatures are required to kill the spores of *B. cereus*. (See Chapter 7, Section 2-B for additional information on spores.)

**Pathogenic bacteria can cause foodborne infections OR intoxications.** *Salmonella* is the leading documented cause of foodborne infections in this country. The bacteria that produce foodborne intoxications most often in the United States include *Bacillus cereus*, *Clostridium botulinum* and *Staphylococcus aureus*.

### C. Parasites

Parasites are single or multi-celled organisms that live either within or upon but always at the expense of a host. They are larger than viruses and bacteria; with dimensions usually greater than 10 micrometers ( $\mu\text{m}$ ). One-celled parasites are commonly termed “parasitic protozoa,” although for the purposes of simplicity, “parasites” will be used throughout this manual to refer to both one-celled and other types. **With regard to foodborne illness, parasites only cause infection, not intoxication. And similar to viruses, parasites do not multiply in foods, but can survive in the environment and thus be transported through food.**

## CHAPTER 2

---

Often, parasites go through structural changes during their life cycles. The structural form transmissible through food often is a cyst that is inert and resistant to the environment outside the host, similar to a bacterial spore but less resistant to heat. Once the cyst, by means of food, enters the body of a new host, it can multiply.

One-celled parasites occurring in foodborne outbreaks in the United States include *Entamoeba histolytica*, *Toxoplasma gondii* and *Giardia lamblia*. *Cryptosporidium parvum* is becoming more common and is also a problem in immunocompromised people, e.g., patients with acquired immune deficiency syndrome (AIDS). *Cyclospora cayetanensis* is a newly recognized parasite that was first reported in the medical literature in 1979. Cases have been identified and reported with increased frequency since the mid-1980s. During the summers of 1996 and 1997, nationwide outbreaks of cyclosporiasis occurred from the consumption of imported, contaminated berries.

The multi-celled parasites found in food may occur as eggs, larvae, or other forms. They can be ingested into the body where they may hatch, leading to the development of new parasites. *Trichinella spiralis* is reported to cause a few cases of foodborne illness (trichinosis) in the United States each year. Formerly, this was an important pathogen associated with undercooked pork. Tapeworm species occurring in the United States include the beef tapeworm (*Taenia saginata*), the pork tapeworm (*Taenia solium*), and the fish tapeworm (*Diphyllobothrium species*). Infection from these is rare.

## 2) Classification of Foodborne Illness

**FOODBORNE INFECTION.** A foodborne infection is caused by ingestion of food contaminated by either viruses, bacteria or parasites, and occurs in one of two ways:

- 1) Viruses, bacteria or parasites in ingested food invade and multiply in the intestinal mucosa and/or other tissues.
- 2) Bacteria in ingested food invade and multiply in the intestinal tract and then release a toxin or toxins that damage surrounding tissues or interfere with normal organ or tissue function. This type of infection is sometimes referred to as a **toxin-mediated infection**. *Viruses and parasites are not able to cause a toxin-mediated infection.*

**FOODBORNE INTOXICATION.** A foodborne intoxication is caused by ingestion of food already contaminated by a toxin. Sources of toxin are:

- 1) certain bacteria,
- 2) poisonous chemicals (e.g., heavy metals like copper), or
- 3) toxins found naturally or formed in animals, plants or fungi (e.g., certain fish and shellfish, certain wild mushrooms).

*Viruses and parasites are unable to cause intoxications.*

### 3) Clinical Features of Foodborne Illness

#### A. Transmission of Pathogens

Most foodborne illness occurs through **fecal-oral transmission**. A disease-causing organism is shed in human or animal feces and is deposited on a food item which is then eaten. A contaminated food item may result in infection if: :

1. raw food contaminated with a pathogen is not cooked long enough to kill the pathogen or is consumed raw (e.g., chicken, eggs or sushi), or
2. cooking utensils are used on a raw food contaminated with a pathogen, then the same utensils are used on another uncooked food (e.g., knife used to cut chicken is also used to cut lettuce for salad).

In addition, a non-contaminated product may become contaminated when handled by an infected food handler who failed to wash his/her hands after using the bathroom and before handling food. Any of these routes of contamination may occur in either a home setting or in a commercial operation such as a restaurant and may result in one or two cases of illness or a large number of ill individuals.

<b>NOTE:</b> More information on food microbiology can be found in Chapter 7, Section 2.
--

#### B. Recognizing Foodborne Illness

The site of illness is usually limited to the gastrointestinal tract, but certain pathogens can move beyond the GI tract to infect other areas of the body. The majority of cases can be described as short-term (24-48 hours) gastroenteritis of abrupt and sometimes violent onset, with median incubation periods ranging from 2 to 36 hours. Signs and symptoms of foodborne illness can range from mild gastrointestinal discomfort to severe reactions that can result in death. **Although signs and symptoms vary, the most common are vomiting, abdominal cramps and diarrhea.** The severity of symptoms depends on many factors discussed throughout Chapter 3. **Because many pathogens are excreted into the feces, infected persons not only experience illness themselves but may be sources of infection to others.**

Investigators often face the problem of having to **implement control measures** before an etiologic agent has been identified. It may be difficult to differentiate between the illnesses and pathogens involved without clinical or lab confirmation. Laboratory analysis is required to make a firm diagnosis, but attention to the symptoms (the time of onset and the presence or absence of some symptoms) may indicate the likely cause and permit a more efficient investigation.

<b>NOTE:</b> See Chapters 5-7 for more information on foodborne illness investigations.
---

Most cases of foodborne disease are single cases, and not associated with a recognized outbreak. Most occur secondary to exposures in the home or at a party, barbecue or

## CHAPTER 2

---

picnic as opposed to restaurant exposure. **Single cases are difficult to associate with a particular food or establishment unless there is a distinctive clinical syndrome OR the same agent responsible for the illness is also identified in the food.** An example of a distinctive clinical syndrome is fish-borne ciguatera poisoning that produces GI symptoms as well as pronounced and persistent neurosensory symptoms such as a sensation of loose teeth, the inability to identify hot by taste or touch, and numbness and pain in the extremities.

**Outbreaks of foodborne disease are usually recognized by the occurrence of illness among people who eat one or more foods in common AND the illness occurs within a short period of time from each other.** While laboratory analysis is pending, it is important to focus on the incubation period. The incubation period in relation with the clinical symptoms is useful in determining an etiologic agent.

### C. Foodborne Infections

Foodborne infections are a consequence of the growth of a microorganism in the human body, and this growth can take varying amounts of time. **Thus, the incubation period is generally rather long, usually measured in days compared to hours with that for most foodborne intoxications.** (For example, the incubation period for salmonellosis is usually 12-48 hours, but can be four days.) **Symptoms of infection usually include diarrhea, nausea, vomiting and abdominal cramps. Fever is often associated with infection.**

The organisms causing infection often possess colonization or adherence factors, allowing them to attach and to multiply in specific parts of the intestine. For example, *Giardia lamblia* trophozoites attach to the upper small bowel. When the numbers become large, they can cover the absorptive surface and interfere with nutrient uptake. *Vibrio cholerae*, the agent of cholera, colonizes the intestine and produces a toxin (cholera toxin) causing an outpouring of fluid from the exposed cells. Death of the patient from dehydration is possible. *Shigella* species erode the intestinal lining, causing shigellosis, or “bacillary dysentery.”

Other organisms can move beyond the GI tract to infect other tissues. Hepatitis A virus appears to infect intestinal cells and then spread to liver cells leading to the predominant manifestation of the disease, inflammation of the liver. *Salmonella typhi* may enter the bloodstream and spread throughout the body, causing typhoid fever. However, most serotypes of *Salmonella* penetrate the intestinal lining without progressing beyond the deeper layers into other tissues. Toxins produced by *E. coli* O157:H7 and other toxigenic *E. coli* can adhere to cells in the intestines, kidneys, and central nervous system, prevent protein synthesis, and cause cell death. Depending on the site of action, the result can be hemorrhagic colitis, hemolytic uremic syndrome, or thrombotic thrombocytopenic purpura. (See Chapter 3, Section 2 for additional information on infections beyond the GI tract.)

## DISEASE CHARACTERIZATION

**TABLE 2.1 Classification of *Escherichia coli* Associated with Diarrhea**

<u>Types of <i>E. coli</i></u>	<u>Epidemiology</u>	<u>Type of Diarrhea</u>
Enteropathogenic	Acute and chronic endemic and epidemic diarrhea in infants	Watery
Enterotoxigenic	Infantile diarrhea in developing countries and traveler's diarrhea	Watery
Enteroinvasive	Diarrhea with fever in all ages	Bloody or nonbloody
Enterohemorrhagic (e.g., <i>E. coli</i> O157:H7)	Hemorrhagic colitis and hemolytic uremic syndrome (see Box 2.2) in all ages and thrombotic thrombocytopenic purpura in adults	Bloody or nonbloody

Source: Data adapted from American Academy of Pediatrics, 1994 Red Book.

### BOX 2.2 What is Hemolytic Uremic Syndrome (HUS)?

- Life threatening illness affecting the kidneys and clotting mechanisms of blood.
- In North America occurs commonly after an *E. coli* O157:H7 infection.
- First described in 1955, but first linked to *E. coli* O157:H7 in 1983.
- Predominantly affects infants and children.
- Most common cause of acute renal failure in children.

Chronic medical conditions (sequelae) may be associated with infections from foodborne pathogens. The incidence of sequelae after foodborne illness is unknown but probably less than 5%. Susceptibilities differ and may be linked to several host risk-factors that are discussed further in Chapter 3.

### D. Foodborne Intoxications

Foodborne intoxications most often result from bacteria that release toxins into food during growth in the food. The preformed toxin is ingested, thus, live bacteria do not need to be consumed to cause illness. Microbial toxins such as botulinum toxin and many of the marine algal toxins are some of the most potent toxins known. Indications that a food contains a preformed toxin (changes in appearance, odor or taste) are rare.

**Illness from an intoxication manifests more rapidly because the body is affected quickly by the toxin or wants to expel it. Time for growth and invasion of the intestinal lining, as in an infection, is not required. The incubation period for an intoxication is often measured in minutes or hours.** For example, the incubation period for *Staphylococcus aureus* toxin-related illness is one to six hours, with a mean of four hours. In cases of paralytic shellfish poisoning (PSP) (caused by the eating of shellfish containing a potent algal toxin) symptoms may be experienced within 15 minutes of ingestion.

## CHAPTER 2

The most common or sometimes only symptom of an intoxication is vomiting. Other symptoms can range from nausea and diarrhea to interference with sensory and motor functions (e.g., taste, touch, muscle movements). These include: double vision, weakness, respiratory failure, numbness, tingling of the face and disorientation. Fever is rarely present with intoxication. Absence of fever is important when trying to determine cause of illness.

**TABLE 2.3 Clinical Features of the Main Types of Foodborne Illness**

Usual Incubation	Typical Symptoms	Possible Cause
<b>Short</b>		
1-5 hours	Vomiting, nausea, sometimes diarrhea and cramps	<i>Bacillus cereus</i>
2-6 hours	Vomiting, nausea, diarrhea	<i>Staphylococcal aureus</i>
<b>Intermediate</b>		
8-18 hours	Diarrhea, abdominal pain	<i>Clostridium perfringens</i>
8-16 hours	Diarrhea, abdominal pain	<i>Bacillus cereus</i>
<b>Long</b>		
12-24 hours	Nausea, vomiting, diarrhea lasting 1-2 days	Small round structured viruses (Norwalk like)
12-24 hours	Diarrhea, abdominal pain	<i>Vibrio parahaemolyticus</i>
12-36 hours	Weakness, double vision, difficulty swallowing, dry mouth	<i>Clostridium botulinum</i>
12-48 hours	Diarrhea, fever, abdominal pain lasting several days	Salmonella species
1-2 days	Diarrhea, often bloody	<i>E. coli</i> (toxigenic species)
1-3 days	Abdominal pain, bloody and mucoid diarrhea, fever	Shigella species
2-5 days	Diarrhea (sometimes bloody), abdominal pain, fever	Campylobacter species
7-10 days	Very watery diarrhea, nausea, vomiting, gas, malaise, weight loss	Cyclospora
1-2 weeks	Diarrhea, bloating	<i>Cryptosporidium parvum</i>
1-3 weeks	Fever or constipation	<i>Salmonella typhi</i>
15-50 days	Jaundice, malaise, fever, diarrhea	Hepatitis A
1-10 weeks	Mild "flu," malaise, meningitis	<i>Listeria monocytogenes</i>

Source: Data adapted from Department of Health, *Mgt. of Outbreaks of Foodborne Illness*, London, 1994.



## DISEASE CHARACTERIZATION

For a typical intoxication to occur, bacteria must be able to multiply and produce toxins in food. In some cases, toxigenic bacteria can contaminate foods and not produce toxin. Therefore, the presence of bacteria does not always mean that the food is hazardous to eat. On the other hand, bacteria may have grown in a food and produced the toxin, yet the bacteria are no longer viable or recoverable. Nevertheless, the toxin remains and causes illness.

The ability to detect the toxin in food, therefore, is more important than the ability to detect bacterial cells. It is more expensive and technologically difficult to detect toxins than bacteria. Currently, animal bioassays are being replaced by new molecular methods. A type of bioassay using mice is still required for detection of botulinum toxin. (See Chapter 6, Section 4-F for information on botulism testing.) **When testing for toxin in food is unavailable, identification of a large number of bacteria can be circumstantial evidence of toxin presence.** There are currently no laboratory tests to detect toxin within an individual.

**TABLE 2.4 Summary of Foodborne Infection and Foodborne Intoxication**

	<b>Foodborne Infection</b>	<b>Foodborne Intoxication</b>
<b>Incubation Period</b>	Generally rather long, usually measured in days	Generally rather short, often measured in minutes or hours
<b>Typical Symptoms</b>	Diarrhea, nausea, vomiting, abdominal cramps. Fever is often present.	Vomiting is more common. Can range from nausea to vomiting to interference with taste, touch and muscle movements (e.g., double vision, weakness, numbness, tingling of face, disorientation, flushing)
<b>Pathogens</b>	<u>Infection:</u> <i>Salmonella</i> species, Hepatitis A, <i>Shigella</i> species, <i>Giardia lamblia</i> <i>Campylobacter</i> species, <i>Yersinia</i> species, <i>Listeria monocytogenes</i> , <i>Vibrio parahaemolyticus</i> , <i>Vibrio vulnificus</i> , rotavirus, Norwalk virus, <i>Toxoplasma gondii</i> , <i>Cyclospora cayetanensis</i> , <i>Cryptosporidium parvum</i> <u>Toxin-mediated infection:</u> <i>C. botulinum</i> (infant), <i>B. cereus</i> (long incubation), <i>E. coli</i> species, <i>V. cholerae</i> , <i>C. perfringens</i>	<i>C. botulinum</i> (adult), <i>S. aureus</i> <i>B. cereus</i> (short incubation), certain metals, certain wild mushrooms, certain fish and shellfish

## CHAPTER 2

---

### E. Examples of Seafood Intoxications

In North America, several kinds of seafood-associated toxins can cause illness.

- **Paralytic shellfish poisoning (PSP)** is transmitted to humans through mussels, clams, and scallops that have ingested and concentrated toxic marine protozoa. The toxin is found mainly in coastal waters and is often associated with a red discoloration of seawater due to algal bloom known as “red tide.”
- **Diarrhetic shellfish poisoning** is also caused by ingestion of seafood containing toxic marine protozoa. Illnesses have occurred in eastern Canada, Japan and western Europe.
- **Amnesic shellfish poisoning** can result from eating shellfish that are contaminated with algae that produces domoic acid. It was responsible for over 100 cases and 3 deaths in eastern Canada in a 1987 outbreak.
- **Ciguatera poisoning** is a result of ingestion of ciguatoxin and related toxins, produced in tropical fish, but also implicated in farm-raised salmon. Areas of higher risk are the Pacific and northern Caribbean. However, imported fish have occasionally caused outbreaks in the United States.
- **Scombroid poisoning**, arising from bacterial spoilage of fish and subsequent production of histamine and related compounds, occurs more frequently than other seafood toxin poisonings. Tuna, mackerel, mahi-mahi and marlin are often implicated.

None of these toxins mentioned above are not destroyed by heat or cold storage, and control depends on the preprocessing stages.

<p><b>NOTE:</b> See Table 2.5 at the end of this chapter for a more complete listing of typical symptoms of common agents.</p>
--

<p><b>NOTE:</b> The quantity (also called “dose”) of viruses, bacteria and parasites necessary to cause illness depends on a number of factors that are discussed further throughout Chapter 3. Table 3.3 also provides the infective/toxic dose of various agents.</p>
---

### 4) The Carrier State

**Foodborne disease carriers are individuals who harbor a specific infectious agent but do not exhibit symptoms of illness or disease. Because the agent is excreted in the feces, a carrier is a potential source of infection for others.**

Characteristics of carriers are listed below.

- Carriers may be people in the incubation phase (the period before symptoms appear) of an infection. In the period before illness, an infected person may excrete the infective agent (e.g., the hepatitis A virus is excreted for as long as two weeks before symptoms appear).
- Certain individuals who are exposed to a contaminated food or become infected never show signs of illness, but as healthy carriers can spread pathogens unknowingly to others. They may show no symptoms either because they have a subclinical infection or because they are only mildly infected. This is particularly dangerous in a food-handling setting.
- Carriers may be people in the convalescent (recovery) stages of an illness. Certain microorganisms can be excreted into feces during the convalescent period, often 24-72 hours after symptoms cease. This is true for viruses, *Salmonella* species, and *Shigella* species. Approximately 1% of patients continue to excrete nontyphoidal *Salmonella* for more than 1 year.
- The carrier state can be of short or long duration (temporary or chronic carrier). The carrier state usually ceases spontaneously after several weeks or a few months, but some individuals may become chronic carriers (e.g., for periods exceeding a year, for agents such as *Salmonella typhi*).

Carrier states are important to remember when investigating and controlling foodborne illness. It is not only individuals with symptoms who are capable of transmission to others, but also those who are in the incubation or convalescent phases of illness and those who are asymptomatic. For example, when determining the close contacts who need prophylactic immune globulin (IG) in a hepatitis A outbreak, it is necessary to identify the onset date of symptoms in the patient and then identify those individuals who may have had close contact with the patient for as long as two weeks prior to that date.

<b>NOTE:</b> See Appendix A, Section 5, for detailed information on hepatitis A control measures.
---

## CHAPTER 2

---

### Conclusion

The next chapter (Chapter 3) discusses the pathogenesis of foodborne illness. It expands further on issues addressed in this chapter. These issues focus on the development of disease among people who eat the same contaminated food. Why do some people get sick when others do not? Why is the severity of symptoms different among those who get ill? Why do some people develop chronic medical conditions when others do not? What quantity of bacteria, virus or parasite (infective or toxic dose) does it take to cause illness?

### References

American Academy of Pediatrics. *1994 Red Book: Report of the Committee on Infectious Diseases*. Illinois: American Academy of Pediatrics, 1994.

American Medical Association. *Foodborne Disease and Food Safety*. Wisconsin: American Medical Association, 1981.

Archer, D.L. and Kvenberg, J.E. Incidence and Cost of Foodborne Diarrheal Disease in the United States. *Journal of Food Protection* 1985; 48: 887-894.

Brock, T. and Brock, K. *Basic Microbiology With Applications-Second Edition*. New Jersey: Prentice-Hall, Inc., 1978.

CAST (Council For Agriculture Science And Technology). *Foodborne Pathogens, Risks and Consequences. Task Force Report, No. 122*, September 1994.

CDC. Surveillance for Foodborne Disease Outbreaks - United States, 1988-1992. *MMWR* 1996; Vol. 45, No. SS-5.

CDC. Viral Agents of Gastroenteritis. *MMWR*. 1990; Vol. 39, No. RR-5.

Cliver, D.O. Epidemiology of Viral Foodborne Disease. *Journal of Food Protection* 1994a; 57:263-266.

Cliver, D.O. 1994b. Viral Foodborne Disease Agents of Concern. *Journal of Food Protection* 1994b; 57:176-178.

DiNubile, M. and Hokama, Y. 1995. The Ciguatera Poisoning Syndrome From Farm-Raised Salmon. *Annals of Internal Medicine* 1995; Volume 122, Number 2.

Doyle, M.P. *Escherichia coli* O157:H7 and its significance in foods. *Inter J. Food Microbiology*. 1991; 112:289-301.

Department of Health. *Management of Outbreaks of Foodborne Illness*. London: Department of Health, December 1994.

Flanagan, P.A. Giardia-Diagnosis, Clinical Course and Epidemiology. A Review. *Epidemiol. Infection* 1992; 109:1-22.

ICMSF (International Commission on Microbiological Specifications for Foods). Toronto: University of Toronto Press, 1978.

Institute of Food Technologists. Foodborne Illness: Role of Home Food Handling Practices. *Food Technology*. Vol. 49, No. 4, April 1995.

Olsvik, O. et al. Pathogenic *Escherichia coli* found in Food. *Int. J. Food Microbiol.* 1991; 12:103-113.

Padhye, N.V. and Doyle, M.P. 1992. *Escherichia coli* O157:H7. Epidemiology, pathogenesis, and methods for detection in food. *Journal of Food Protection* 1992; 55:555-565.

Popovic, T., Olsvik, O. and Blake, P.A. Cholera in the Americas: Foodborne Aspects. *Journal of Food Protection* 1993; 56:811-821.

Riemann, H. and Bryan, F.L. *Foodborne Infections and Intoxications*. 2<sup>nd</sup> ed. New York: Academic Press, 1979.

Smith, J.L. 1993a. Cryptosporidium and Giardia as Agents of Foodborne Disease. *Journal of Food Protection* 1993a; 56:451-461.

Soave, R. Cyclospora: An Overview. *Clinical Infectious Diseases* 1996; 23: 429-437.

Sterksy, A.K. et al *Staphylococcus aureus* Growth and Thermostable Nuclease and Enterotoxin Production in Canned Salmon and Sardines. *Journal of Food Protection* 1986; 49:428-435.

## TABLE 2.5

### a) Common Foodborne Diseases Caused by Bacteria

Disease (causative agent)	Latency Period (duration)	Principal Symptoms	Typical Foods	Mode of Contamination	Prevention of Disease
<b>(<i>Bacillus cereus</i>) food poisoning, diarrheal</b>	8-16 hr (12-24 hr)	Diarrhea, cramps, occasional vomiting	Meat products, soups, sauces, vegetables	From soil or dust	Thorough heating and rapid cooling of foods
<b>(<i>Bacillus cereus</i>) food poisoning, emetic</b>	1-5 hr (6-24 hr)	Nausea, vomiting, sometimes diarrhea and cramps	Cooked rice and pasta	From soil or dust	Thorough heating and rapid cooling of foods
<b>Botulism; food poisoning (heat labile toxin of <i>Clostridium botulinum</i>)</b>	12-36 hr (months)	Fatigue, weakness, double vision, slurred speech, respiratory failure, sometimes death	Types A & B: vegetables, fruits, meat, fish, and poultry products, condiments; Type E: fish and fish products	Types A & B: from soil or dust; Type E: water and sediments	Thorough heating and rapid cooling of foods
<b>Botulism; food poisoning infant infection</b>	Unknown	Constipation, weakness, respiratory failure, sometimes death	Honey, soil	Ingested spores from soil, dust or honey colonize intestine	Do not feed honey to infants - will not prevent all
<b>Campylobacteriosis (<i>Campylobacter jejuni</i>)</b>	3 - 5 days (2 - 10 days)	Diarrhea, abdominal pain, fever, nausea, vomiting	Infected food-source animals	Chicken, raw milk	Cook chicken thoroughly; avoid cross- contamination; irradiate chickens; pasteurize milk
<b>Cholera (<i>Vibrio cholerae</i>)</b>	2 - 3 days hours to days	Profuse, watery stools; sometimes vomiting, dehydration; often fatal if untreated	Raw or undercooked seafood	Human feces in marine environment	Cook seafood thoroughly; general sanitation
<b>(<i>Clostridium perfringens</i>) food poisoning</b>	8 - 22 hr (12 - 24 hr)	Diarrhea, cramps, rarely nausea and vomiting	Cooked meat and poultry	Soil, raw foods	Thorough heating and rapid cooling of foods
<b>(<i>Escherichia coli</i>) foodborne infections enterohemorrhagic</b>	12-60 hr (2-9 days)	Watery, bloody diarrhea	Raw or undercooked beef, raw milk	Infected cattle	Cook beef thoroughly; pasteurize milk
<b>(<i>Escherichia coli</i>) enteroinvasive</b>	at least 18 hr (uncertain)	Cramps, diarrhea, fever, dysentery	Raw foods	Human fecal contamination, direct or via water	Cook foods thoroughly; general sanitation
<b>(<i>Escherichia coli</i>) foodborne infection: enterotoxigenic</b>	10-72 hr (3-5 days)	Profuse watery diarrhea; sometimes cramps, vomiting	Raw foods	Human fecal contamination, direct or via water	Cook foods thoroughly; general sanitation
<b>Listeriosis (<i>Listeria monocytogenes</i>)</b>	3-70 days	Meningoencephalitis; still- births; septicemia or meningitis in newborns	Raw milk, cheese and vegetables	Soil or infected animals, directly or via manure	Pasteurization of milk; cooking
<b>Salmonellosis (<i>Salmonella</i> species)</b>	5-72 hr (1-4 days)	Diarrhea, abdominal pain, chills, fever, vomiting, dehydration	Raw and undercooked eggs; raw milk, meat and poultry	Infected food-source animals; human feces	Cook eggs, meat, and poultry thoroughly; pasteurize milk; irradiate chickens
<b>Shigellosis (<i>Shigella</i> species)</b>	12-96 hr (4-7 days)	Diarrhea, fever, nausea; sometimes vomiting, and cramps	Raw foods	Human fecal contamination, direct or via water	General sanitation; cook foods thoroughly
<b>Staphylococcal food poisoning (heat-stable enterotoxin of <i>Staphylococcus aureus</i>)</b>	1-6 hours (6-24 hours)	Nausea, vomiting, diarrhea, cramps	Ham, meat and poultry products, cream-filled pastries, whipped butter, cheese	Handlers with colds, sore throats or infected cuts, food slicers	Thorough heating and rapid cooling of foods
<b>Streptococcal foodborne infection (<i>Streptococcus pyogenes</i>)</b>	1-3 days (varies)	Various, including sore throat, erysipelas, scarlet fever	Raw milk, deviled eggs	Handlers with sore throats, other “strep” infections	General sanitation, pasteurize milk
<b><i>Vibrio</i> <i>parahaemolyticus</i> foodborne infection</b>	12-24 hr (4-7 days)	Diarrhea, cramps; sometimes nausea, vomiting, fever headache	Fish and seafoods	Marine coastal environment	Cook fish and seafoods thoroughly
<b><i>Vibrio vulnificus</i> foodborne infection</b>	In persons with high serum iron: 1 day	Chills, fever, prostration, often death	Raw oysters and clams	Marine coastal environment	Cook shellfish thoroughly
<b>Yersiniosis (<i>Yersinia enterocolitica</i>)</b>	3-7 days (2-3 weeks)	Diarrhea, pains mimicking appearance of appendicitis, fever, vomiting, etc.	Raw or undercooked pork and beef; tofu packed in spring water	Infected animals especially swine; contaminated water	Cook meats thoroughly, chlorinate water

## b) Common Foodborne Diseases Caused by Viruses

Disease (Causative agent)	Onset (Duration)	Principal Symptoms	Typical Foods	Mode of Contamination	Prevention of Disease
<b>Hepatitis A</b> (Hepatitis A virus)	15-50 days (weeks to months)	Fever, weakness, nausea, discomfort, often jaundice	Raw or undercooked shellfish; sandwiches, salads, etc.	Human fecal contamination, via water or direct	Cook shellfish thoroughly; general sanitation
<b>Viral gastroenteritis</b> (Norwalk-like viruses)	1-2 days (1-2 days)	Nausea, vomiting, diarrhea, pains, headache, mild fever	Raw or undercooked shellfish, sandwiches, salads, etc.	Human fecal contamination, via water or direct	Cook shellfish thoroughly; general sanitation
<b>Viral gastroenteritis</b> (rotaviruses)	1-3 days (4-6 days)	Diarrhea, especially in infants and children	Raw or mishandled food	Probably human fecal contamination	General sanitation

## c) Common Foodborne Diseases Caused by Fungi Other Than Mushrooms

Disease (Causative agent)	Latency Period (Duration)	Principal Symptoms	Typical Foods	Mode of Contamination	Prevention of Disease
<b>Aflatoxicosis</b> ("aflatoxins" of <i>Aspergillus flavus</i> and related molds)	Varies with dose	Vomiting, abdominal pain, liver damage; liver cancer (mostly Africa and Asia)	Grains, peanuts, milk	Molds grow on grains and peanuts in field or storage; cows fed moldy grain	Prevent mold growth; don't eat or feed moldy grain or peanuts; treat grain to destroy toxins
<b>Alimentary toxic aleukia</b> ("trichothecene" toxin of <i>Fusarium</i> molds)	1-3 days (weeks to months)	Diarrhea, nausea, vomiting; destruction of skin and bone marrow; sometimes death	Grains	Mild growth on grain, especially if left in the field through winter	Harvest grain in the fall; don't use moldy grain
<b>Ergotism</b> (toxins of <i>Claviceps purpurea</i> )	Varies with dose	Gangrene (limbs die and drop off); or convulsions and dementia; abortion (now not seen in the U.S.)	Rye; or wheat, barley, and oats	Fungus grows on grain in the field; grain kernel is replaced by a "sclerotium"	Remove sclerotia from harvested grain

## d) Common Foodborne Diseases Caused by Protozoa and Parasites

Disease (Causative agent)	Onset (duration)	Principal Symptoms	Typical Foods	Mode of Contamination	Prevention of Disease
<b>(PROTOZOA) Amebic dysentery</b> ( <i>Entamoeba histolytica</i> )	2-4 weeks (varies)	Dysentery, fever, chills; sometimes liver abscess	Raw or mishandled foods	Cysts in human feces	General sanitation; thorough cooking
<b>Cryptosporidiosis</b> ( <i>Cryptosporidium parvum</i> )	1-12 days (1-30 days)	Diarrhea; sometimes fever, nausea, and vomiting	Mishandled foods	Oocysts in human feces	General sanitation; thorough cooking
<b>Giardiasis</b> ( <i>Giardia lamblia</i> )	5-25 days (varies)	Diarrhea with greasy stools, cramps, bloat	Mishandled foods	Cysts in human and animal feces, directly or via water	General sanitation; thorough cooking
<b>Toxoplasmosis</b> ( <i>Toxoplasma gondii</i> )	10-23 days (varies)	Resembles mononucleosis; fetal abnormality or death	Raw or undercooked meats; raw milk; mishandles foods	Cysts in pork or mutton, rarely beef; oocysts in cat feces	Cook meat thoroughly; pasteurize milk; general sanitation
<b>(ROUNDWORMS, Nematodes) Anisakiasis</b> ( <i>Anisakis simplex</i> , <i>Pseudoterranova decipiens</i> )	Hours to weeks (varies)	Abdominal cramps, nausea, vomiting	Raw or undercooked marine fish, squid or octopus	Larvae occur naturally in edible parts of seafoods	Cook fish thoroughly or freeze at -4°F for 30 days
<b>Ascariasis</b> ( <i>Ascaris lumbricoides</i> )	10 days-8 weeks (1-2 years)	Sometimes pneumonitis, bowel obstructions	Raw fruits or vegetables that grow in or near soil	Eggs in soil, from human feces	Sanitary disposal of feces; cooking food
<b>Trichinosis</b> ( <i>Trichinella spiralis</i> )	8-15 days (weeks, months)	Muscle pain, swollen eyelids, fever; sometimes death	Raw or undercooked pork or meat or carnivorous animals (e.g., bears)	Larvae encysted in animal's muscles	Thorough cooking of meat; freezing pork at 5°F for 30 days; irradiation
<b>(TAPEWORMS, Cestodes) Beef tapeworm</b> ( <i>Taenia saginata</i> )	10-14 weeks (20-30 years)	Worm segments in stool; sometimes digestive disturbances	Raw or undercooked beef	"Cysticerci" in beef muscle	Cook beef thoroughly or freeze below 23°F
<b>Fish tapeworm</b> ( <i>Diphyllobothrium latum</i> )	3-6 weeks (years)	Limited; sometimes vitamin B-12 deficiency	Raw or undercooked fresh-water fish	"Plerocercoids" in fish muscle	Heat fish 5 minutes at 133°F or freeze 24 hours at 0°F
<b>Pork tapeworm</b> ( <i>Taenia solium</i> )	8 weeks-10 years (20-30 years)	Worm segments in stool; sometimes "cysticercosis" of muscles, organs, heart, or brain	Raw or undercooked pork; any food mishandled by a <i>T. solium</i> carrier	"Cysticerci" in pork muscle; any food-human feces with <i>T. solium</i> eggs	Cook pork thoroughly or freeze below 23°F; general sanitation

### e) Common Foodborne Diseases Caused by Chemicals and Metals

Disease (causative agent)	Latency Period (duration)	Principal Symptoms	Typical Foods	Mode of Contamination	Prevention of Disease
<b>(TOXINS IN FINFISH)</b> <b>Ciguatera poisoning</b> (ciguatera toxin, etc.)	3-4 hr (rapid onset)  12-18 hr (days-months)	Diarrhea, nausea, vomiting, abdominal pain  Numbness and tingling of face; taste and vision aberrations, sometimes convulsions, respiratory arrest and death (1-24 hrs)	“Reef and island” fish: grouper, surgeon fish, barracuda, pompano, snapper, etc.	(Sporadic); food chain, from algae	Eat only small fish
<b>Fugu or pufferfish poisoning (tetrodotoxin, etc.)</b>	10-45 min to $\geq 3$ hrs	Nausea, vomiting, tingling lips and tongue, ataxia, dizziness, respiratory distress/arrest, sometimes death	Pufferfish, “fugu” (many species)	Toxin collects in gonads, viscera	Avoid pufferfish (or their gonads)
<b>Scombroid or histamine poisoning (histamine, etc.)</b>	minutes to few hours (few hours)	Nausea, vomiting, diarrhea, cramps, flushing, headache, burning in mouth	“Scombroid” fish (tuna, mackerel etc.); mahi- mahi, others	Bacterial action	Refrigerate fish immediately when caught
<b>(TOXINS IN SHELLFISH)</b> <b>Amnesic shellfish poisoning</b> (domoic acid)		Vomiting, abdominal cramps, diarrhea, disorientation, memory loss; sometimes death	Mussels, clams	From algae	Heed surveillance warnings
<b>Paralytic shellfish poisoning</b> (saxitoxin, etc.)	<1 hr (<24 hr)	Vomiting, diarrhea, paresthesias of face, sensory and motor disorders; respiratory paralysis, death	Mussels, clams, scallops, oysters	From “red tide” algae	Heed surveillance warnings
<b>(MUSHROOMS TOXINS)</b> <b>Mushroom poisoning</b> (varies greatly among species)	<2 hrs to $\geq 3$ days	Nausea, vomiting, diarrhea, profuse sweating, intense thirst, hallucinations, coma, death	Poisonous mushrooms	Intrinsic	Don’t eat wild mushrooms
<b>(PLANT TOXINS)</b> <b>Cyanide poisoning</b> (cyanogenetic glycosides from plants)	(Large doses) 1-15 min	Unconsciousness, convulsions, death	Bitter almonds, cassava, some lima bean varieties, apricot kernels	Intrinsic, natural	Proper processing; avoid some so- called foods
<b>(METALS) Cadmium</b>	Depends on dose	Nausea, vomiting, diarrhea, headache, muscular aches, salivation, abdominal pain, shock, liver damage, renal failure	Acid foods, food grilled on shelves from refrigerator	Acid or heat mobilizes cadmium plating	Select food contact surfaces carefully
<b>Copper poisoning</b>	Depends on dose (24-48 hours)	Nausea, vomiting, diarrhea	Acid foods, foods contacting copper	Acid mobilizes copper	Select food contact surfaces carefully
<b>Lead poisoning</b>	Depends on dose	Metallic taste, abdominal pain, vomiting, diarrhea, black stools, oliguria, collapse, coma (also chronic effects)	Glazes, glasses, illicit whiskey	Lead dissolves in beverages and foods	Test glazes and glasses; avoid illicit whiskey
<b>Mercury poisoning</b>	Depends of dose	Metallic taste, thirst, abdominal pain, vomiting, bloody diarrhea, kidney failure	Treated seeds (fungicide); fish	Intentional; food chain	Eat only seeds intended for food
<b>Zinc poisoning</b>	Depends on dose (24-48 hr)	Nausea, vomiting, diarrhea	Acid foods in galvanized containers	Acid mobilizes zinc plating	Select food contact surfaces carefully

Source: Institute of Food Technologists, *Food Technology*, 1995. Used with permission.